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(54) Compact disc analyzer system.

(57) A system for testing compact discs having intelligible information and time subcode information thereon in which three microprocessors respectively monitor the HF signal, the radial tracking signal and the decoder digital flags produced by a CD player to produce error signals indicating HF dropout, HF low, modulation amplitude, radial tracking, Burst, Bler, and uncorrectable errors and in which a computer having a memory responds to the time signal produced by the player periodically to transfer the contents of the microprocessors to the memory together with the time of transfer and to reset the microprocessors. Initially an eccentricity test is performed and the entire test is stopped if the eccentricity is excessive. The computer is programmed to display the test results in various formats.

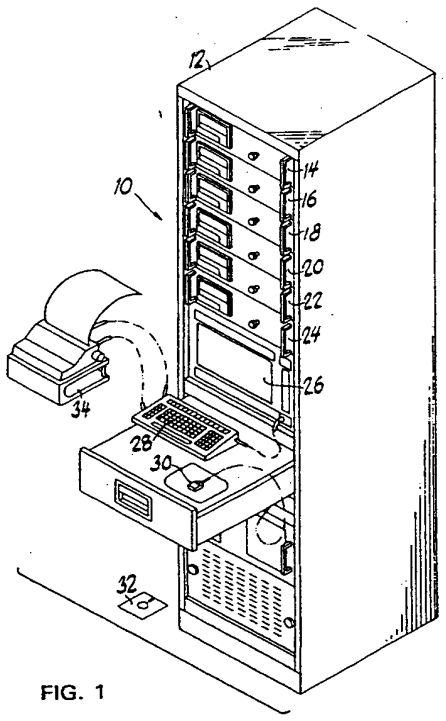

FIG. 1

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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 397 126 (MITSUBISHI) * page 4, column 6, line 31 - page 8, column 14, line 52; figures *	1-3,10, 11,20, 21,26,27	G11B20/18
A	EP-A-0 309 639 (DISCOVISION) * page 4, line 22 - page 16, line 15; figures *	1-3,10, 11,20, 21,26,27	
A	EP-A-0 144 831 (POLYGRAM) * page 3, line 22 - page 16, line 34; figures *	1-3,10, 11,20, 21,26,27	
A	PATENT ABSTRACTS OF JAPAN vol. 15, no. 460 (P-1278) 21 November 1991 & JP-A-03 194 778 (SONY) 26 August 1991 * abstract *	1-3,10, 11,20, 21,26,27	TECHNICAL FIELDS SEARCHED (Int.Cl.5) G11B
A	PATENT ABSTRACTS OF JAPAN vol. 15, no. 435 (P-1272) 6 November 1991 & JP-A-03 181 033 (SONY) 7 August 1991 * abstract *	1-3,10, 11,20, 21,26,27	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 October 1994	Geoghegan, C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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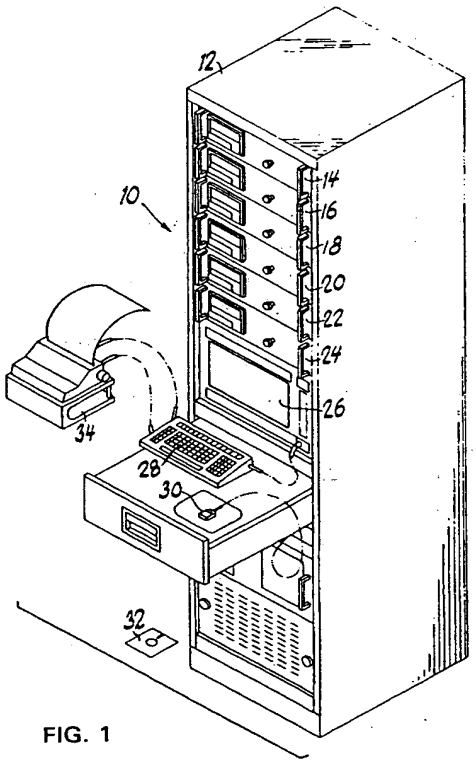

FIG. 1

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Field of the Invention

The invention is in the field of electrical test devices and more particularly relates to a compact disc analyzer system which overcomes the defects of testers of the prior art.

Background of the Invention

As is known in the art, compact discs (CDs) must meet relatively stringent mechanical and electrical requirements. Further as is known in the art, a CD player reads a CD by means of a laser beam which is caused by a servo system to follow the spiral track of information recorded on the disc. In the course of this operation, a radial error system is generated. Further, the player produces a high frequency output signal representing the information contained in the pits on the track. The player also provides information as to time of play of selections. The player includes a first decoder which is designed to correct random errors. A second decoder is able to correct random errors which the first decoder was unable to correct. These decoders flag errors which have occurred.

Manufacturers of compact discs are required to meet certain requirements set by the licensee having the right to make copies of the performance and who orders production of the disc. These specifications set limits on the number and kinds of errors in a disc. Such errors include digital errors flagged by the player decoders and high frequency signal errors as well as radial tracking error and eccentricity.

Some tests of CDs have been made in the prior art in an effort to detect errors of the type described above. While such testers are in some degree successful, they are not as reliable as is desired. We have found that testers of the prior art are unreliable in that they do not produce the same result with any degree of consistency. That is to say, the same disc can be played a number of times with different results obtained each time. Stated otherwise, the result of the test is not repeatable. There is, moreover, no way of knowing where the error occurred on the disc.

Summary of the Invention

One object of our invention is to provide a compact disc tester which overcomes the defects of testers of the prior art.

Another object of our invention is to provide a compact disc tester which is reliable.

A further object of our invention is to provide a compact disc tester which is certain in operation.

Still another object of our invention is to provide a compact disc tester which produces substantially the same result for a plurality of tests of the same disc.

Yet another object of our invention is to provide a compact disc tester which records errors and the location of the errors.

Other and further objects of our invention will appear from the following description.

Brief Description of the Drawings

In the accompanying drawings to which reference is made in the instant specification and which are to be read in conjunction therewith and in which like reference characters are used to indicate like parts in the various views:

FIG. 1 is a perspective view of our compact disc analyzer system illustrating the major components thereof.

FIG. 2 is a block diagram of our CD analyzer system.

FIG. 3 is a schematic diagram of the wiring diagram of the compact disc player component of our CD analyser system.

FIG. 4 is a schematic diagram of a first portion of the high frequency chip of our CD analyser system.

FIG. 5 is a schematic diagram of the remaining portion of the high frequency chip of our CD analyzer system.

FIG. 6 is a schematic diagram of the radial tracking chip of our CD analyzer system.

FIG. 7 is a schematic diagram of the microcontroller component of our CD analyzer system.

FIG. 8A is a schematic diagram of a first portion of the dual port memory of our CD analyzer system.

FIG. 8B is a schematic diagram of the remaining portion of the dual port memory of our CD analyser system.

FIG. 9 is a diagrammatic view illustrating the steps performed in the course of making the eccentricity test in our system.

FIG. 10 is a diagrammatic view illustrating the steps performed in the course of determining the radial error in our system.

FIG. 11 is a diagrammatic view illustrating the steps performed in the course of generating high frequency error signals.

FIG. 12 is a diagrammatic view illustrating the steps performed in carrying out a compact disc test in our system.

Description of the Preferred Embodiment

Referring now to FIG. 1 of the drawings, our CD analyzer system indicated generally by the reference character 10 includes a cabinet 12 adapted to house up to six drawers, 14, 16, 18, 20, 22

and 24, each of which holds a CD player to be described more fully hereinbelow. As will be explained further, our system may be operated in such a manner as to perform the required test or tests using only a single player or as many as six players to expedite the test.

Our system includes a main computer such as an XYCOM 4140-AT2 provided with a display screen 26. A keyboard 28 having 101 keys, such for example as that made by Jameco Electronics is associated with the main computer. The system includes a two button mouse 30 and a disk 32 encoding the software to be described more fully hereinbelow, as well as an eighty column dot matrix printer 34 of any suitable type known to the art.

Referring now to FIG. 2, the basic CD analyzer includes a main user interface/analysis computer 36, a dual port memory 38, six supervising microcontrollers 40, signal acquisition microcontrollers including a high frequency board 42 and a radial tracking board 44 and a compact disc player 46 adapted to play a disc 48.

It is to be understood that we may use either a single player 46 or a plurality of players housed in the drawers 14, 16, 18, 20, 22 and 24. For purposes of simplicity in FIG. 2, we have illustrated only the first player 46 and the last player 50 where a multiplicity of players are used. It is to be understood that individual microcontrollers 40, high frequency boards 42, and radial tracking boards 44 are provided for the individual players with the dual port memory 38 and the computer 36 being shared among the plurality of boards. For example, a supervising microcontroller 52, a high frequency board 54 and a radial tracking board 56, may be associated with the last player 50.

The computer 36 monitors and analyzes information from the microcontrollers 40 and 52. Through the operator it controls the testing of the compact disc. As is known in the art, it can display the results on screen 26 or print the test results on the printer 34.

As will be explained more fully hereinbelow, each of the supervising microcontrollers, such as the controller 40, takes error information from the error decoders of the associated player 48 through a channel 58 and sends suitable signals to the player through a channel 60.

The supervising controller, such as controller 40, communicates with the HF board 42 through channels 62 and 64 and with the radial tracking board 44 by means of the HF board through channels 66 and 68. Board 42 receives information from the player 46 through a channel 70. Board 44 receives its information from the player 46 through the channel 72.

The dual port memory 38 provides memory which is shared between the supervising microcontrollers 40 and 52 and the like and the computer 36. It transfers commands and information. It is divided into partitions, with each partition being assigned to one supervising microcontroller.

Referring now to FIG. 3, each of the compact disc players such for example as the player 46, may be of any suitable type known to the art, such for example as a Sony model 3000 player. Connections are made to the player in order to extract the desired readily available information. For example, conductors 74, 76, 78 and 80 may carry the error information from the error decoders of the compact disc player C1F1, C1F2, C2F1 and C2F2. Conductors 82, 84 and 86 carry RFCLK, MUTEG, and DOOR-SW information. Conductors 88, 90, 92 and 94 respectively carry RS422PTX, RS422NTX, RS422PRX, and RS422NRX subcode signals. The audio left signal is on conductors 96 and 98, while the audio right signal is on conductors 100 and 102. These conductors may be connected to a suitable cable terminal indicated generally by the reference character 104 to which an earphone 106 may be connected to permit the operator to monitor the player.

We extract high frequency information from the player 46 by means of a cable 108 which is connected to elements 110 and 112 of a cable receptacle indicated generally by the reference character 114. It will also be seen that we connect lines 114, 116, 118, 120, 122, 124, 126, 128 and 130 carrying signals AGND, SPA1, XINT, XDATA, XACK, PWR OK, PWR IN, SPA2 and GND to elements of the receptacle 114. Radial tracking information from the player 46 is carried by a cable 132 to elements 134 and 136 of a cable receptacle indicated generally by the reference character 138. A coaxial connector 140 connects elements 142 and 144 of receptacle 138 to a RELAY input of the player 46 to disable the disc constant linear speed during the eccentricity test.

Referring now to FIG. 4, a conductor 146 applies the HF signal appearing in elements 110 and 112 of receptacle 114 to an analog to digital converter 148 which, in response to suitable signals AD ENA and AD CVT on lines 150 and 152, converts the HF signal to a digital output appearing on a bus 154 as AD DATA, Ø-11. The converter 148 may be of any suitable type known to the art, such for example as a THC 1202.

A conductor 156 applies the signal on line 146 to a differential amplifier indicated generally by the reference character 158. This amplifier converts the high frequency signal into a quasi AC so that rectifiers indicated generally by the reference characters 160 and 162 can handle the signal. The rectified outputs produced by the rectifiers 160 and 162 are applied to the inputs of comparators 164 and 166. Comparator 164 is connected in a manner

which will be apparent to those skilled in the art to provide a high frequency dropout (DO) signal. Comparator 166 is so connected as to provide a high frequency low (HFL) signal.

A first pair of filtering circuits 168 and 170 remove the noise from the output of comparator 164 to provide a high frequency dropout DO signal on a conductor 172. A second pair of filtering circuits 174 and 176 remove the noise from the output of comparator 166 to provide a high frequency low HFL signal on a conductor 178.

Referring now to FIG. 5, a crystal oscillator source 180 and three NAND circuits 182, 184 and 186 provide an input to each one of three DIVIDE BY 16 circuits 188, 190 and 192. These dividers may for example be 74ALS163B. Circuit 188 provides bits AD ADDØ-3 to a bus 194. Similarly the circuits 190 and 192 apply groups of bits AD ADD3-7 and AD ADD8-11 to the bus 194 which is connected to the left hand ports of a dual port RAM 196 which may be a 1 DT 71 33 PGA, for example.

A three input NAND circuit 198 responsive to inputs from circuits 189, 190 and 192 provides an input for a flip-flop 200 which generates the chip select for the memory 196. Conductor 152 carrying the CVT signal is connected to the output of the NAND circuit 186. Conductor 150 carrying the ENA signal is connected to the RAM 196. Bus 154 carrying the AD DATA1-11 bits is connected to the left lower ports of RAM 196.

A bus 202 leading from the supervisory microprocessor to be described hereinbelow, carries bits UC ADØ-15. Respective bidirectional buffers 204 and 206 transfer groups of bits UC AD1-8 and UC AD9-15 to a bus 208 coupling DP ADDØ-1Ø to the upper right-hand ports of the RAM 196. A second pair of bidirectional buffers 210 and 212 couple UC ADØ-7 and UC AD8-15 to a bus 214 which couples DP DATAØ-7 and DP DATA8-15 to the lower right group of ports of the RAM 196.

Bus 202 also couples UC ADØ-15 to the groups of ports P3.Ø-7 and P4.Ø-7 of a microcontroller 216 which may for example be an 87C196LCC. Respective inverters 219 and 220 couple conductors 172 and 178 carrying DO and HFL to the HS1.1 and HS1.Ø ports of converter 216. We connect the element 119 of receptacle 114 to a bidirectional buffer 218 which couples the signal to the microcontroller 216. The terminal of the buffer 218 carrying the XACK OUT signal is connected to the element 123 of receptacle 114. The receptacle element 121 carrying the XDATA signal is connected to the P1.7 port of microcontroller 216, the P1.6 port of which is connected to the buffer 218. A conductor 221 connects the PØ.Ø port of controller 216 to the dividers 188, 190 and 192.

Respective conductors 222 and 224 carrying the SERIAL RX and SERIAL TX signals are applied to the P2.Ø and P2.1 ports of controller 216.

Referring now to FIG. 6, which shows the radial tracking portion of the circuitry, conductors 226 and 228 connect the elements 134 and 136 of receptacle 138 carrying the radial tracking signal to two series-connected high pass filter circuits 230 and 232. A comparator 236 responsive to the output of the filter circuits provides an output on conductor 238 as a measure of the peak-to-peak value of the HF signal.

A conductor 240 applies the output of filter circuit 232 to the input of two series-connected low pass filter circuits 242 and 244, the output of which is applied to a comparator 248 which produces an output on line 250 which is a measure of the RMS value of the high frequency signal. We apply the signals on conductors 238 and 250 to the PØ.Ø andPØ.1 ports of a microcontroller 252. A transistor 254 couples the elements 142 and 144 of receptacle 138 to a bidirectional buffer 256. We couple the P2.6 and P2.7 ports of controller 252 to the buffer 256 to disable the disc drive at the proper time and to determine the status of a pair of light emitting diodes 258 and 260 corresponding respectively to "eccentricity" and to "status". Respective conductors 262 and 264 carrying RAD RX and RAD TX are connected to the P2.Ø and P2.1 ports of microcontroller 252. A bus 266 carrying ADØ-15 is connected to the groups of ports P3.Ø-7 and P4.Ø-7 of the microcontroller 252.

Referring now to FIG. 7, the supervisory microcontroller circuit of our CD tester system includes a microcontroller 266 which may for example be an 87C196LCC. A bus 268 carries the signals on lines 120, 122, 124, 126 and 128 and other possible signals to the microcontroller 266. From the bus 268 we apply the PWR OK, the SPARE 2, the CAL IN and the SPARE 3 to the PØ.Ø and PØ.4-6 ports of the microcontroller 266. A first output level translator 270 responsive to the subcode signals on lines 88 and 90 applies an input to the P2.Ø port of controller 266. A second output level translator responsive to the subcode signals on lines 88, 90, 92 and 94, applies its outputs to ports P2.1 and P2.3 of controller 266. We apply the X INT signal on line 118 to the port P2.2.

A buffer 274 is adapted to couple the signals on lines 78, 80, 76, and 74 respectively to the ports HSØ.4, HSØ5, HS1.1 and HS1.Ø of the controller 266.

A first multivibrator 276 responsive to the RFCLK signal on line 82 and to the output of a NAND circuit 280 responsive to the MUTEG signal on line 84, actuates a second multivibrator 278, the output of which is applied to buffer 274.

As indicated by the dot-dash lines in the upper right-hand corner of FIG. 7, the buffer 274 is adapted to couple the MICRO ALE, MICRO WRH,

MICRO WRL and MICRO RD signals to the controller 266. A conductor 282 applies the MICRO ENA signal to buffer 274.

A pair of bidirectional buffers 284 and 286 couple MICRO AD BUS Ø-7 and MICRO AD BUS 8-15 to a bus 280 from which the groups of signals are coupled to ports P3.Ø-7 and ports P4.Ø-7 of the controller 266. Conductor 282 also applies the MICRO ENA signal to buffers 282 and 284. A conductor 285 applies the READ signal from buffer 274 to the buffers 284 and 286.

A transistor 290 couples DOOR SW on conductor 86 to the P1.3 port of controller 266. A conductor 292 applies the PLAYER 0 signal to the P1.Ø port of controller 266. A five-input NAND circuit 304 couples lines 294, 296, 298, 300 and 302 carrying the respective PLAYER 1 to PLAYER 5 signals to the P1.1 port of controller 266. Conductor 282 is connected to the P1.2 port. The X DATA and X ACK signals from bus 268 are connected to the P1.5 and P1.6 ports.

Referring now to FIGS. 8A and 8B, the dual port memory circuit of our system includes a dual port RAM 306. We apply the main computer address signals AT-SA 12-19 to a comparator 308. A DIP switch 310 is adapted to be set to provide the other inputs for comparator 308. As is known in the art, when the computer address signals applied to comparator 308 correspond to the signals from the DIP switch 310, comparator 308 puts out a signal indicating the correspondence.

A bus 312 couples the computer address signals AT SA1-11 to a pair of buffers 314 and 316. We apply the computer AT SDØ-7 signals to a pair of bidirectional buffers 318 and 320. The outputs of buffers 314 and 316 lead to the ports AØR to A1ØR of memory 306. The left hand ports of buffers 318 and 320 are connected to the 100R to 1015R ports of the memory 306. An array of NOR circuits and inverters indicated generally by the reference character 322 responsive to the signals SA0, WR and RD provide respective signals on lines 324 and 326 which, together with the output of the comparator 308, enable the buffers 318 and 320 to couple the lines SDØ through SD7 to the 10ØR through 1015R ports of memory 306. We connect the IO CH RDY line 328 to buffer 316.

A conductor 330 connects the RD line to the OER port of memory 306. The array 322 provides two other signals on lines 332 and 334 connected to the RWRL and RWRU ports of memory 306. A conductor 336 couples the output of comparator 308 to the CER port. Buffer 316 provides an input for the BUSY R port.

Respective bidirectional buffers 338 and 340 are adapted to transfer signals between a bus 342 carrying the MICRO AD BUS Ø-15 and the 10ØL to 1015L ports of the memory 306.

A bidirectional buffer 343 is adapted to couple the MICRO ALE, MICRO WRH, MICRO WRL and MICRO RD lines at the upper right-hand corner of FIG. 7 to a bus 344 to apply these signals together with a BUSY signal to the OEL RWLU and RWLL ports of memory 306 and to an inverter 346.

A NAND circuit 348 from the ALE line provides one input for a flip-flop 350, the other input of which is provided by series connected NAND circuits 352 and 354, the first of which receives its inputs from the WRH, WRL and RD lines. Flip-flop 350 generates a chip select signal for the dual port memory which is applied to the CE OUT port of memory 306.

A third buffer 352 is adapted to couple the MICRO AD BUS 1-8 lines to the AØL to A7L ports of memory 306.

Respective PLAYER Ø-5 lines from the CD players are connected to a partition select circuit 354, one output of which controls the buffers 338, 340 and 352, and the other three outputs of which are fed through respective inverters to the A8L through A1ØL ports of memory 306. The memory 306 is a 2KX16 memory. The function of the element 354 is to divide the available memory by eight so that one-quarter K of memory is reserved for each of the players. The arrangement is such that when we want any of the players or drawers to communciate with the main computer, the corresponding line is taken low and only that player can talk to the corresponding partition of the memory.

When the microcontroller 40, compact disc player 46, and computer 36 are communicating, the controller checks the signal acquisition cards, whether there is a compact disc present and whether the door of the player is closed. It keeps the door closed during a test by keeping the compact disc player in the on-line mode. Then it reads the table of contents of the compact disc 48. The microcontroller 40 positions the compact disc player anywhere on the compact disc as determined by the operator's input and the type of test. The supervisory micro-controller 40 communicates with the Radial and HF boards 42 and 44 to synchronize the eccentricity measurement at the start of the test and to synchronize symmetry, I3 MOD AMP, I11 MOD AMP, and radial tracking from the compact disc during the test. It reports the results to the computer 36 through the dual port memory 38.

In the course of testing a CD, the first operation which is performed is to check the disc for unacceptable eccentricity or the deviation from circularity of the pit track and the positioning of the center hole. Prior to performing this check, transistor 254 of FIG. 6 is energized to produce a signal at terminals 142 and 144 of FIG. 3 which opens a

feedback loop to disable the constant linear velocity drive of the player so that the disc spins at a constant angular velocity while the pickup of the radial tracking signal is stationary. Referring to FIG. 9, this step is indicated by the block 360. Under these conditions, the radial tracking signal is high when it is in register with a track and near zero between tracks. This radial tracking signal from elements 134 and 136 of FIG. 3 is fed to conductors 226 and 228 of the radial tracking error circuitry of FIG. 6 to monitor the signal as indicated by block 362 of FIG. 9. As indicated by block 364, we count the number of peaks per unit time or per revolution of the disc as a measure of eccentricity. The count is compared with a reference, as indicated at 366, to determine whether or not an unacceptable eccentricity exists. If so, the test is stopped at 368. If not, the testing continues. As will be explained more fully hereinbelow, in the course of the continuing test our system checks Bler, Burst, C2un, symmetry, I11, I3, radial tracking, E21, E31, E12, E22, HF low and HF dropouts.

After the eccentricity test is complete, the system returns to normal operation. Basically three things are happening simultaneously, as described under (a), (b) and (c) below.

a) We tap off the error flags directly from the player at 74, 76, 78 and 80 as C1F1, C1F2, C2F1 and C2F2 which are flags from the player decoders C1 and C2, which flags define the error conditions for every block of data as it is clocked through the decoder. The first decoder C1 is designed to correct random errors. C2 is able to correct random errors which C1 was unable to correct. The C1 decoder corrects minor errors and flags uncorrectable errors. The C2 decoder corrects larger errors aided by the error flags. Uncorrected errors from C2 (C2un) are also flagged.

As is known in the art, signals derived from the four flags indicate the number of errors in a frame. For example, from C1 with C1F1 high and C1F2 low, a signal E11 indicates that one error has been corrected in C1. With C1F1 low and C1F2 high, a signal E21 indicates that two errors have been corrected in C1 and with both C1F1 and C1F2 high, signal E31 indicates that there are more than two errors in C1 and the data is passed to C2. The three signals, E11, E21, and E31 are added to provide a block error rate Bler signal indicating the number of errors in a block. At the decoder C2, a signal E22 signals two defect symbols in a frame. The E11 and E12 signals are combined to form a Burst error count. Another signal, C2un indicates the errors which leave C2 uncorrected. In our system, the errors which occur during each second, are accumulated and placed in the dual port memory of FIGS. 8A and 8B. It will be remembered that at the same time the system is reading the serial data RS422 on lines 88, 90, 92 and 94, indicating the time of occurrence of the errors.

The microcontroller board 40 takes the error information C1F1, C1F2, C2F1 and C2F2 from the error decoders of the player 46. Counters on the microcontroller board decode and count the number of C1F2 (E21), E31, Burst, Bler, C2F1 (E12), C2F2 (E22), C2un, HF low, and HF dropouts that occur in a second. After the counters are placed in the dual port memory each second the counters in the controllers are reset to zero. The microcontroller board 40 also reads serial RS422 information from the compact disc player 46 every frame. The serial data contains the track, index, track time and absolute time of the compact disc.

b) The player includes a servo system which generates a radial analog signal which causes the laser spot to follow the disc track. As indicated by block 370 of FIG. 10, we monitor the radial analog signal at terminals 134 and 136 of FIG. 3. As is pointed out hereinabove, the radial tracking signal at terminals 134 and 136 of FIG. 3 is applied to conductors 226 and 228 of FIG. 6 to produce peak-to-peak and RMS signals on conductors 238 and 250. The filtering steps which result in the peak-to-peak and RMS signals are indicated by blocks 376 and 378 of FIG. 10. This effectively separates the signal into two parts, one of which contains all of the information from a point up and the other of which contains all the information from a point down. These are applied to two different terminals of the microcontroller 252. As indicated by blocks 376 and 378 of FIG. 10, two inputs are digitized internally of the controller 252. We then divide the peak-to peak signal by the RMS signal and multiply the result by a constant to get the running radial noise error at block 380. For example, running radial noise error = Ø.51(P-P/RMS).

The radial tracking board 44 processes the radial tracking signal in order to calculate the eccentricity and radial tracking value. The eccentricity value is determined at the beginning of a test only, while radial tracking is calculated throughout the test. This information is sent to the HF board 42, once per second, which passes it to the supervisory microcontroller board 40.

c) The photodiode and its processing circuits produce a signal resembling a high frequency sine wave called the EFM signal and sometimes referred to as the RF or HF signal. We monitor this signal at terminals 110 and 112 to obtain HF

low and HF dropout, as indicated in FIG. 4 at 178 and 172. Referring to FIG. 11, after monitoring the signal as indicated at block 382, it is rectified as indicated at blocks 384 and 388 and the rectified signals are compared with references at 386 and 390 to provide error signals. The signal is also digitized at 148 to search for specific parameters such as I3 and I11. I3 and I11 are measures of modulation amplitude or minimum and maximum pit length. In this connection we have noticed that owing to the player electronics there is actually an overshoot in the waveforms representing I3 and I11. Since I3 does not go into saturation there is no way of seeing the overshoot. We detect the overshoot on the I11 pulse and subtract it from the I3 pulse so that we have an accurate measure of I3.

More specifically, referring again to FIG. 11, the HF signal is digitized at block 392 and is stored in the microprocessor memory at 394. The microprocessor memory is then scanned, looking at every point and the delta, or difference, between points. Clearly, when the curve is flat the delta should be small and during the slope the delta is large. In measuring the overshoot, we first take the peak, or maximum signal, which is the overshoot, and then wait for the deltas to get very small. When that occurs we average over a couple of points and say that is the true top. This true top is subtracted from the peak to get the overshoot. This operation is represented by block 396. That number is then subtracted from the I3 number.

After the I3 and I11 signals are computed at 398 with the overshoot subtracted at 400, we divide both I3 and I11 by I top which is the highest value read which is the modulation amplitude. The result is the I3 modulation amplitude and the I11 modulation amplitude which are the values checked and stored. This last operation is represented by block 402.

In the explanation of the operation of our system given hereinbelow, it will be understood that the main computer 36 communicates with one side of the dual port memory 38 and that the microcontroller units including units 40, 42 and 44 communicate with the other side of the dual port memory 38. Data is collected by the microcontrollers and put into the dual port memory. The main computer 36 then reads the collected data out of the dual port memory and performs the operations for which the computer 36 has been programmed such as comparison of the data with threshold values and the like. All of the necessary calculations take place in the main computer 36. The dual port memory acts like a gateway. It is there as a buffer to hold the information collected by the microcontrollers until the computer has time to access it.

Referring now to FIG. 12, from a start at 404, at 406, we first load the threshold limits into the main computer 36. The threshold limits loaded are those for Bler, Burst, C2un, symmetry high, symmetry low, I11, I3 high, I3 low, radial tracking, E21, E31, E12, E22, HF low and HF dropouts. Next at 408 we perform the eccentricity test as described hereinabove. If the test is failed as at 410, we stop the test at 412.

If the CD passes the eccentricity test, next, as indicated at 404, we continue by collecting the data representing all the parameters of our test. As is indicated by block 424, the data is collected by the microcontroller units including but not limited to units 40, 42 and 44 for a period of one second after which the microprocessor counters are reset at 428 and the data is passed to the dual port memory 38.

As indicated by block 416, the main computer 36 compares the data from the dual port memory 38 with the threshold values previously set into the main computer to detect errors at 418. As indicated by blocks 420 and 422, the main computer stores each maximum or minimum one second value for each parameter being checked as well as the absolute time, track minute and track second. For Bler the computer calculates a ten second running average for the graph. The comparison with the threshold value is the one second reading. Each time the comparison of the parameter in question with the corresponding threshold indicates an error the computer signals the operator and the test continues.

We program the computer 36 to provide the operator with a number of menus for display of the collected data. The SELECT TEST menu permits the operator to select which six plot screen to display--Red Book or Indicative, to do a full test, partial test, continue a test, zoom in on a plot screen, or to exit the test on the compact disc.

The six plot Red Book screen consists of Bler, Burst, C2un, Symmetry, I11 & I3 MOD AMP and radial tracking. Bler, Burst, and C2un are plotted on a logarithmic scale for the error counters (Ø.5 to 999) verses the absolute time of the compact disc. I11 & I3 MOD AMP are plotted from Ø to 1 verses the absolute time of the compact disc. Radial tracking is plotted from Ø to 50 nano-meters verses the absolute time of the compact disc. After the initial 40 seconds, the data is displayed on the plots every 20 seconds. The information is not plotted for 40 seconds in order to collect enough data to do a running ten second average for Bler. If any error values exceeds the threshold limits, a bell will ring. The plotted data is always twenty seconds behind collected data because of averaging.

The window 26 allows the operator to select tests. Time information is displayed as track, index, track time, absolute time, and remaining time.

Maximum or minimum one second errors are displayed as follows: Bler, Burst, C2un, SymHi, SymLo, I11, I3Hi, I3Lo, radial tracking and Burst Magnitude along with the track time which they occurred. The disc identification information is displayed for the operator in order to determine which compact disc is being tested.

The six plot Indicative screen consists of E21, E31, E12, E22, HFlow and HF dropouts. E21, E31, E12, E22, HF low and HF dropouts are plotted on a logarithmic scale for the error counters (Ø.5 to 999) versus the absolute time of the compact disc. After the initial 40 seconds, the data is displayed on the plots every 20 seconds. The information is not plotted for 40 seconds in order to collect enough data to do a running ten second average for Bler. If any error value exceeds the threshhold limits, a bell will ring. The plotted data is always twenty seconds behind collected data because of averaging.

Time information is displayed at 26. Maximum one second errors are displayed as follows: E21, E31, E12, E22, HF low, HF dropouts, and eccentricity along with the track time which they occurred. The disc identification information is displayed for the operator in order to determine which compact disc is being tested.

The Full Test pick does a test on a compact disc from the beginning to the end. The cursor is placed on the screen when reaching the end of the music on the compact disc. The time information for the track, index, track time, absolute time, and time remaining are displayed in the window 26 every second as the test runs. The maximum one second error of either the Red Book or Indicative errors are displayed in the window 26 at the beginning of a test. The Red Book or Indicative six plot screens are updated every twenty seconds except for the first plot which takes forty seconds. Twenty seconds is used because this is the smallest amount of time which corresponds to one pixel and can be plotted in the six plot windows. The first plot takes forty seconds in order to get enough data to do a ten second running average for Bler.

It is believed that the other picks on the SELECT TEST menu will be clear without a detailed explanation.

The SCREENS menu allows the operator to select the picks of Bler, Burst, C2un, Sym(metry), I11 & I3, radial tracking, E21, E31, E12, E22, HFlow, HFDO, or Stats plots.

The Bler Plot pick plots the ten second running average Bler error count versus the absolute time on the monitor. The running ten second average Bler is calculated every second from the previous ten second readings. The largest of the ten calculated ten second readings is displayed on the plot. If the running average Bler is greater than 999, it is plotted as 999. However, the original data is kept for other calculations.

For each of the Burst, C2un, E21, E31, E12, E22, HF low and HFDO Plots plots the highest value to occur in a ten second interval versus the absolute time on the monitor. The parameter is read every second. The largest of the ten second readings is displayed on the plot. If the value is greater than 999, it is plotted as 999 and the original data is kept for other calculations.

The Sym(metry) Plot pick plots the highest or lowest Sym to occur in a ten second interval versus the absolute time on the monitor. If Sym is greater than 50% or less than -50%, it is plotted 50% or -50% respectively. However, the original data is kept for other calculations.

The I11 & I3 Plot pick plots the lowest I11 and highest or lowest I3 to occur in a ten second interval versus the absolute time on the monitor. If I11 or I3 is greater than 1 they are plotted as 1. However, the original data is kept for other calculations.

The Rad Plot pick plots the highest radial tracking value to occur in a ten second interval versus the absolute time on the monitor. If radial tracking value is greater than 50 nanometers, it is plotted as 50 nanometers. However, the original data is kept for other calculations.

The Stats pick displays statistical information of the data collected by the CD analyzer on the monitor. Eccentricity is displayed in microns on the top line. The Faults Per Sec. is the type of errors that occurred on the compact disc, which are Bler, Burst, C2un, Sym(metry) high, Sym(metry)low, I11, I3 high, I3 low, Rad(ial) tracking, E21, E31, E12, E22, HFlow, HFDO, and BurstMag. The mean is the average error throughout the entire compact disc which is total error count divided by the total number of seconds played. StdDev is the standard deviation of the errors throughout the entire compact disc. The Max is the maximum one second error which occurred on the compact disc. ATime is the absolute time on the compact disc where the maximum one second error occurred. Tr and TTime is the track and track time where the maximum one second error occurred. The absolute time gives the operator a time so a zoom plot can be displayed to look at the error. The track and track time allows the operator to find the location of the error on the compact disc, so they can replay the compact disc to verify the error.

Further on command by the computer 36, the information can be printed out on printer 34 rather than being displayed at 26.

It will be seen that we have accomplished the objects of our invention. We have provided a compact disc analyzer system which overcomes the defects of testers of the prior art. Our system is

reliable. The result produced by our system is repeatable. Our system records both errors and the time of occurrence of the errors.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

Claims

1. A system for testing a compact disc having sensible information together with a time subcode digitally encoded thereon including in combination a player for reproducing the information on said disc, said player producing signals representing parameters indicating the quality of said disc and a time signal, means for monitoring said parameter signal values, means for storing threshold values of said parameters, means for comparing said monitored parameter values with said threshold values to provide indications of errors in said parameters, and means responsive to said time signal for storing said error indications together with the times of occurrence thereof.

2. A system as in Claim 1 in which said player includes a constant linear speed drive, said player producing a radial tracking signal, said apparatus including means for disabling said constant linear speed drive, said monitoring means including means for monitoring said radial tracking signal with said constant linear drive disabled to produce a measure of eccentricity in said disc.

3. A system as in Claim 1 including means responsive to said time signal comprising means for periodically accumulating said monitored values and said error indications.

4. A system as in Claim 3 in which said monitoring and storing and comparing means and logging means comprises microprocessor means incorporating counters, said accumulating means comprising a counter, said means responsive to said time signal comprising means for periodically transferring the contents of said microprocessor to said memory.

5. A system as in Claim 1 in which said player produces a radial tracking signal, said monitoring means comprising first means for filtering said radial tracking signal to produce a peak-to-peak signal, second means for filtering said radial tracking signal to produce an RMS signal and means for dividing said peak-to-peak signal by said RMS signal to obtain a radial tracking error signal.

6. A system as in Claim 1 in which said player produces a HF signal, means for rectifying said signal, first means for comparing said rectified signal with a first reference value to provide a measure or HF dropouts, and second means for comparing the rectified signal with a second reference to provide a measure of HF lows.

7. A system as in Claim 1 in which said player produces a HF signal, means for digitizing said signal, means for storing said digitized signal, means for analyzing said stored signal to measure the overshoot therein, means for computing the value of I3 from said stored digitized signal and means for subtracting said overshoot from said I3 value.

8. A system as in Claim 1 in which said player produces a HF signal, means for digitizing said signal, means for computing I3 and I11 and I top and means for dividing each of I3 and I11 by I top to obtain minimum and maximum modulation amplitude measures.

9. A system as in 1 in which said player produces a HF signal, means for digitizing said signal, means for storing said digitized signal, means for analyzing said stored signal to measure the overshoot therein, means for computing the values of I3 and I11 and I top from the stored digitized value, means for subtracting the overshoot from the I3 value to obtain a corrected I3 value and means for dividing the corrected I3 value and the I11 value by I top to obtain minimum and maximum modulation amplitude measure.

10. A system as in Claim 1 in which the player puts out decoder flags which define the error conditions for every block of data as it is clocked through the player decoders, said monitoring and comparing means responsive to said decoder flags for providing Burst and Bler errors and for counting Burst and Bler and uncorrectable errors.

11. A system for testing a compact disc having sensible information together with a time subcode digitally encoded thereon including in combination a player for reproducing said information, said player providing a HF output and a radial tracking signal and decoder digital flags and a subcode time signal, first microprocessor means comprising means responsive to said radial tracking signal for producing a running radial error signal, means for comparing said radial error signal with a reference value to produce a first error indication and means for storing said first error indication, second microprocessor means comprising means responsive to said HF signal for deriving HF dropout and HF low and upper and lower modulation amplitude signals, means for comparing said HF dropout and HF low and upper and lower modulation amplitude signals with references to produce second error indications and means for storing said second error indications, third microprocessor means responsive to said decoder digital flags for producing Burst and Bler and uncorrectable error signals, means for comparing said Burst and Bler and uncorrectable error signals with references to produce third error indications and means for storing said third error indications, a computer having a memory and means responsive to said time signal for periodically transferring the contents of said microprocessor means to said memory together with the times of transfer.

12. A system as in Claim 11 in which said first microprocessor means comprises first means for filtering said radial tracking signal to produce a peak-to-peak signal, second means for filtering said radial tracking signal to produce an RMS signal and means for dividing said peak-to-peak signal by said RMS signal to obtain said radial tracking error signal.

13. A system as in Claim 11 in which laid second microprocessor means comprises means for rectifying said HF signal, first means for comparing said rectified signal with a first reference value to provide said HF dropout signal, and second means for comparing the rectified signal with a second reference to provide said HF low signal.

14. A system as in Claim 11 in which said second microprocessor means comprises means for digitizing said HF signal, means for storing said digitized signal, means for analyzing said stored signal to measure the overshoot therein, means for computing the value of I3 from said stored digitized signal and means for subtracting said overshoot from said I3 value.

15. A system as in Claim 11 in which said second microprocessor means comprises means for digitizing said HF signal, means for computing I3 and I11 and I top and means for dividing each of I3 and I11 by I top to obtain said upper and lower modulation amplitude signals.

16. A system as in Claim 11 in which said second microprocessor means comprises means for digitizing said HF signal, means for storing said digitized signal, means for analyzing said stored signal to measure the overshoot therein, means for computing the values of I3 and I11 and I top from the stored digitized value, means for subtracting the overshoot from the I3 value to obtain a corrected I3 value and means for dividing the corrected I3 value and the I11 value by I top to obtain said upper and lower modulation amplitude signals.

17. A system as in Claim 11 in which said first microprocessor means comprises first means for filtering said radial tracking signal to produce a peak-to-peak signal, second means for filtering said radial tracking signal to produce an RMS signal and means for dividing said peak-to-peak signal by said RMS signal to obtain said radial error tracking signal, and in which said second microprocessor means comprises means for rectifying said HF signal, first for comparing said rectified signal with a first reference value to provide said HF dropout signal and second means for comparing said rectified signal with a second reference to provide said HF low signal.

18. A system as in Claim 17 in which said second microprocessor comprises means for digitizing said HF signal, means for computing I3 and I11 and I top and means for dividing each of I3 and I11 by I top to obtain said upper and lower modulation amplitude signals.

19. A system as in Claim 18 in which said second microprocessor means comprises means for analyzing said digitized signal to measure the overshoot therein and means for subtracting the overshoot from said I3 value.

20. A method for testing a compact disc having sensible information together with a time subcode digitally encoded thereon including the steps of playing said disc on a player producing signals representing parameters indicating the quality of the disc and a time signal, monitoring said parameter signal values, comparing

said monitored perimeter values with threshold values of said parameters to provide indications of errors in said parameters and means for storing said errors in a memory periodically in response to said time signal together with an indication of the time at which the storage took place.

21. A method of testing a compact disc having sensible information together with a time subcode digitally encoded thereon including the steps of playing said compact disc on a player which produces a HF output and a radial tracking signal and decoder digital flags and a subcode time signal, processing said radial tracking signal to provide an indication of radial tracking errors, processing said HF signal to provide indications of HF dropouts, HF lows and upper and lower modulation amplitude signals, processing said decoder digital flags to provide Burst and Bler and uncorrectable error signals and storing said error signals in a memory periodically in response to said time signal together with an indication of the time of storage thereof.

22. A method as in Claim 21 in which said step of processing said radial tracking signal comprises the steps of filtering said tracking signal to produce an RMS signal thereof, filtering said tracking signal to produce a peak-to-peak signal thereof and dividing said peak-to-peak signal by said RMS signal.

23. A method as in Claim 21 in which said step of processing said HF signal comprises the steps of rectifying said HF signal, comparing said rectified signal with a first reference to provide said HF dropout indication and comparing said rectified signal with a second reference to provide said HF low signal.

24. A method as in Claim 21 in which said step of processing said HF signal comprises digitizing said HF signal, deriving I3 and I11 and I top from said digitized signal and dividing I3 and I11 by I top to obtain low and high modulation amplitude signals.

25. A method as in Claim 24 in which said step of processing said HF signal comprises analyzing said digitized HF signal to determine overshoot and subtracting said overshoot from I3.

26. A method of determining eccentricity in a compact disc including the steps of playing said disc on a player having a constant linear speed drive and producing a radial tracking signal, disconnecting said constant linear speed drive and counting the number of peaks in said radial tracking signal as a measure of eccentricity.

27. In a method of testing a compact disc, the steps of playing said disc on a player adapted to produce a HF signal, digitizing said HF signal, analyzing said digitized signal to obtain a measure of the overshoot in said HF signal, computing I3 from said digitized signal and subtracting said overshoot from I3.

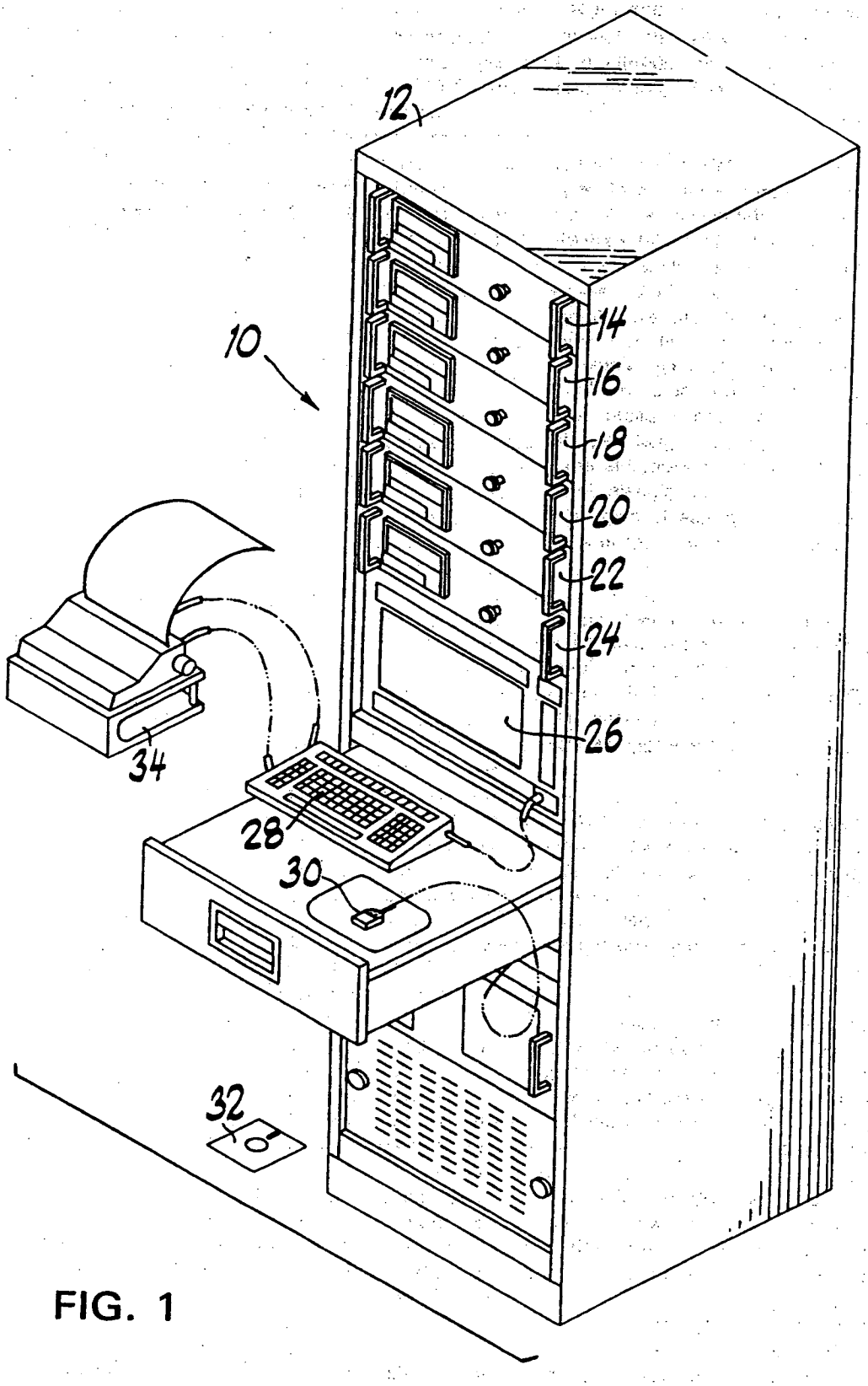

FIG. 1

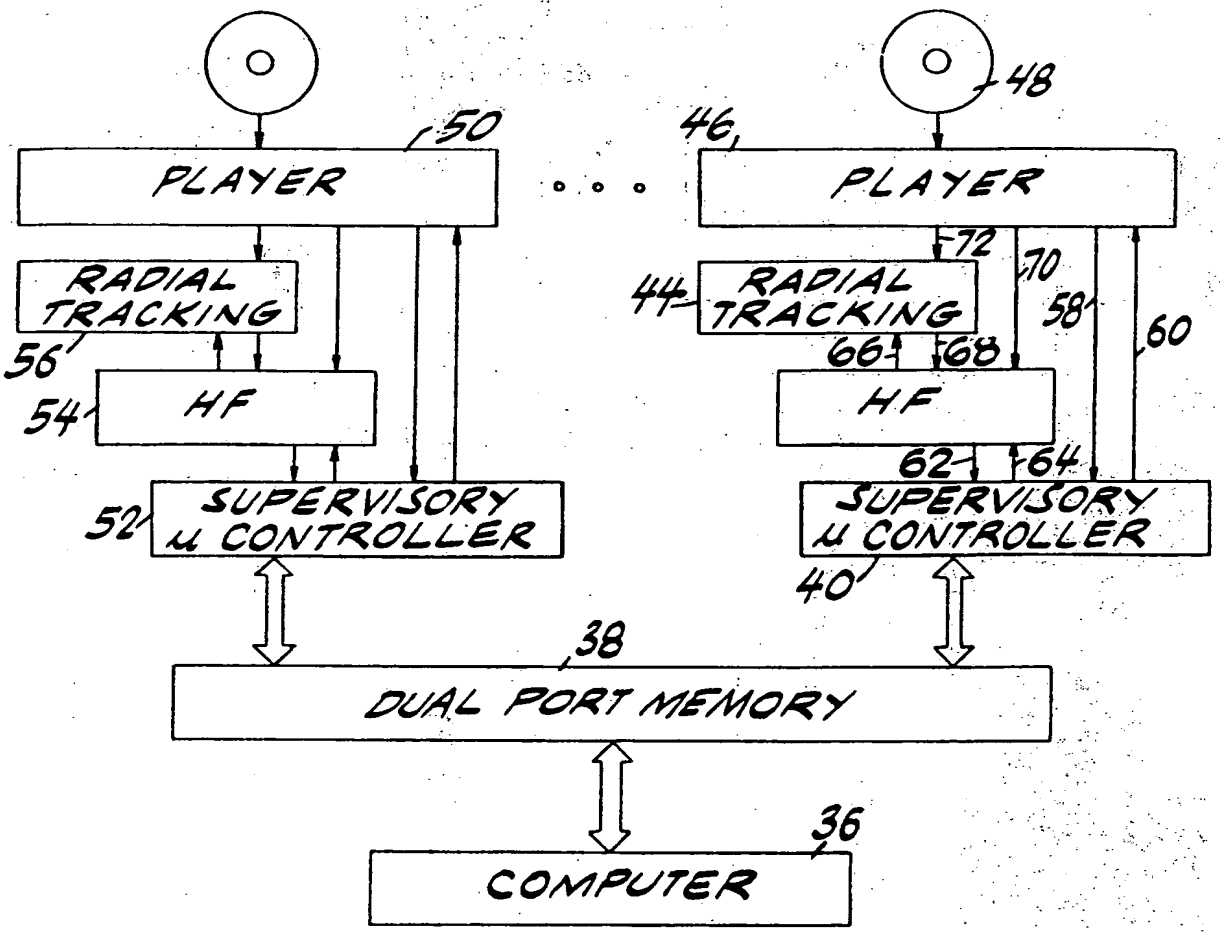
PLAYER
50
46
48
PLAYER
RADIAL TRACKING
56
HF
54
SUPERVISORY μ CONTROLLER
52
72
70
44
RADIAL TRACKING
58
60
66
68
HF
62
64
SUPERVISORY μ CONTROLLER
40
38
DUAL PORT MEMORY
36
COMPUTER

FIG. 2

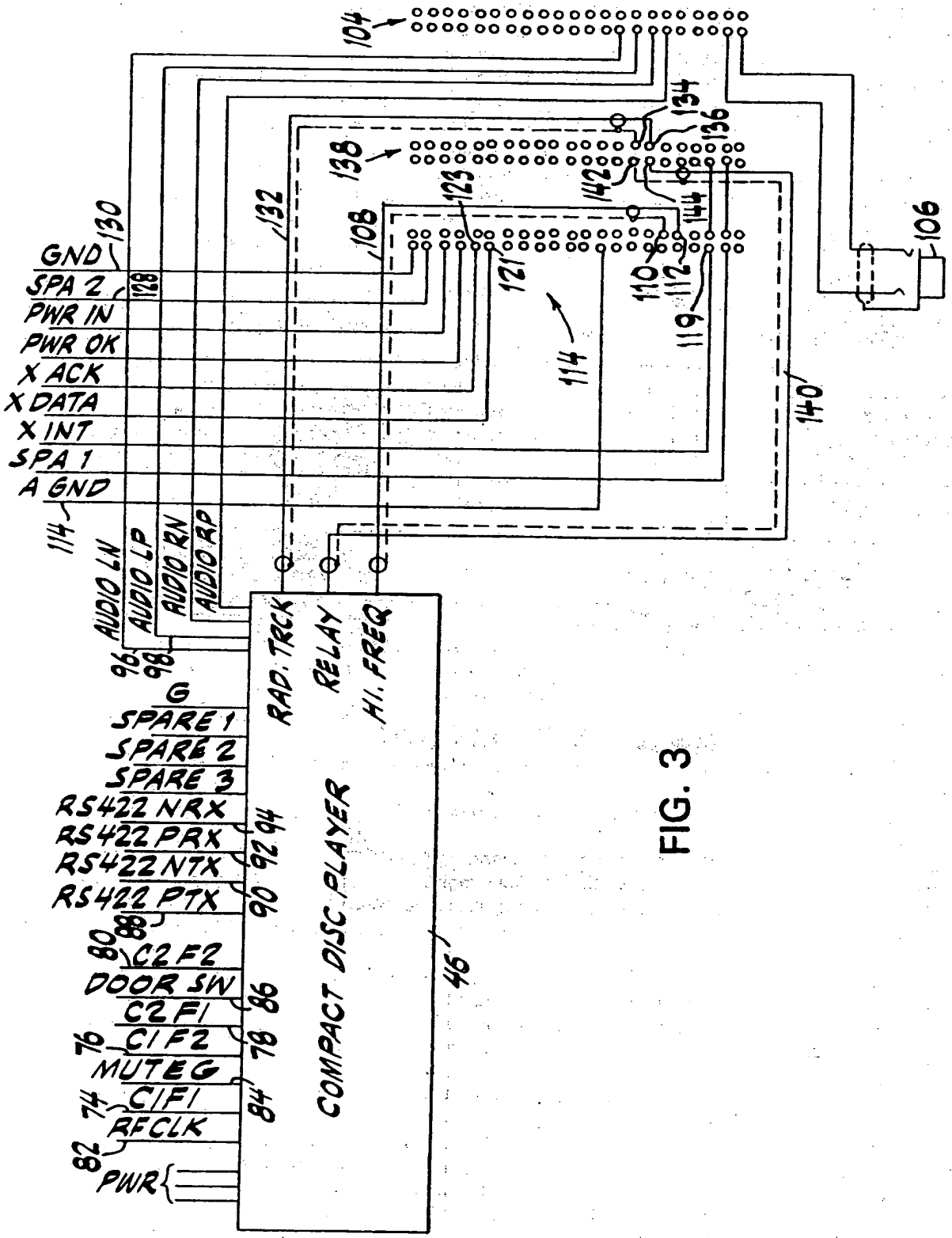
104
134
136
138
142
144
123
132
108
106
130
GND
SPA 2
128
PWR IN
PWR OK
X ACK
X DATA
X INT
SPA 1
A GND
114
121
110
112
119
114
140
AUDIO LN
AUDIO LP
AUDIO RN
AUDIO RP
96
98
RAD. TRCK
RELAY
HI. FREQ
G
SPARE 1
SPARE 2
SPARE 3
RS422 NRX
RS422 PRX
RS422 NTX
RS422 PTX
94
92
90
88
80
C2 F2
DOOR SW
C2 F1
86
C1 F2
78
76
MUTE G
C1 F1
84
74
RFCLK
82
PWR
COMPACT DISC PLAYER
46

FIG. 3

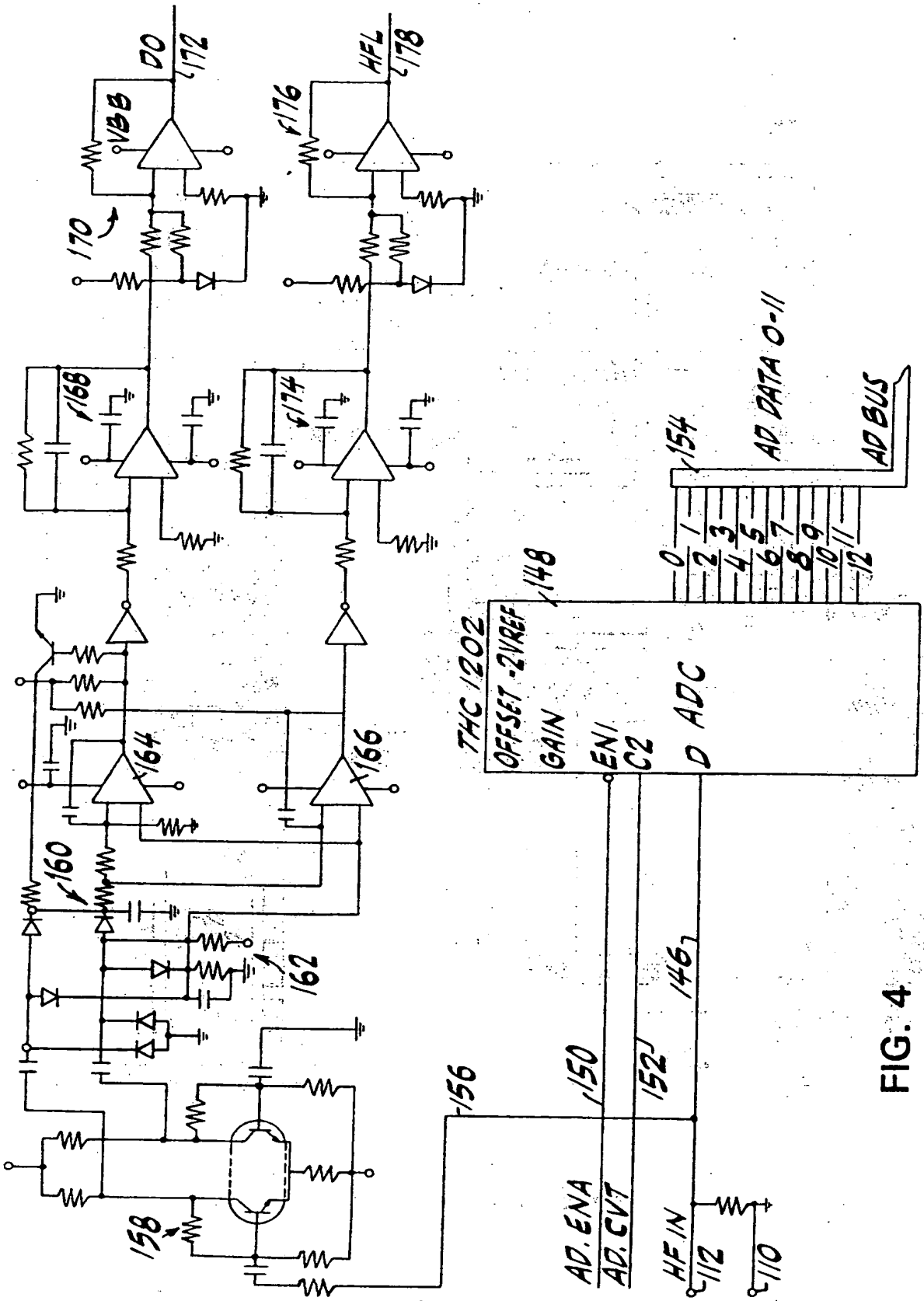
DO
172
HFL
178
176
170
168
174
164
166
160
162
158
156
150
152
146
148
154
AD DATA 0-11
AD BUS
0
1
2
3
4
5
6
7
8
9
10
11
12
THC 1202
OFFSET -2VREF
GAIN
ENI
C2
D ADC
AD. ENA
AD. CVT
HF IN
112
110

FIG. 4.

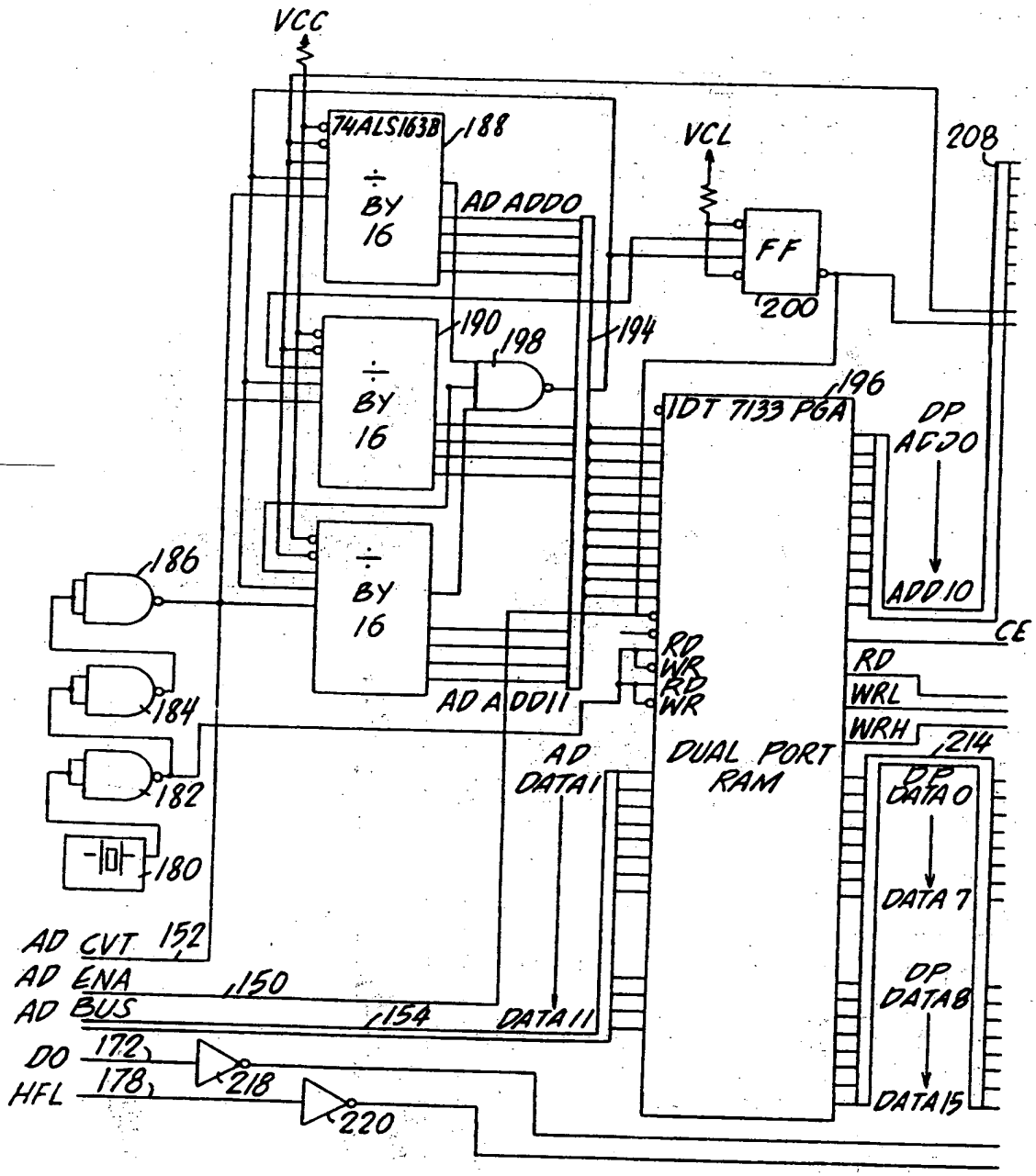
VCC
74ALS163B
188
÷ BY 16
AD ADDO
VCL
208
FF
200
190
198
194
÷ BY 16
IDT 7133 PGA
196
DP ADDO
ADD10
186
÷ BY 16
CE
RD
WR
RD
WR
RD
WRL
WRH
214
184
AD ADD11
AD DATA1
DUAL PORT RAM
DP DATA 0
182
DATA 7
180
AD CVT 152
AD ENA 150
AD BUS 154
DATA11
DP DATA8
DO 172
HFL 178
218
220
DATA15

FIG. 5A

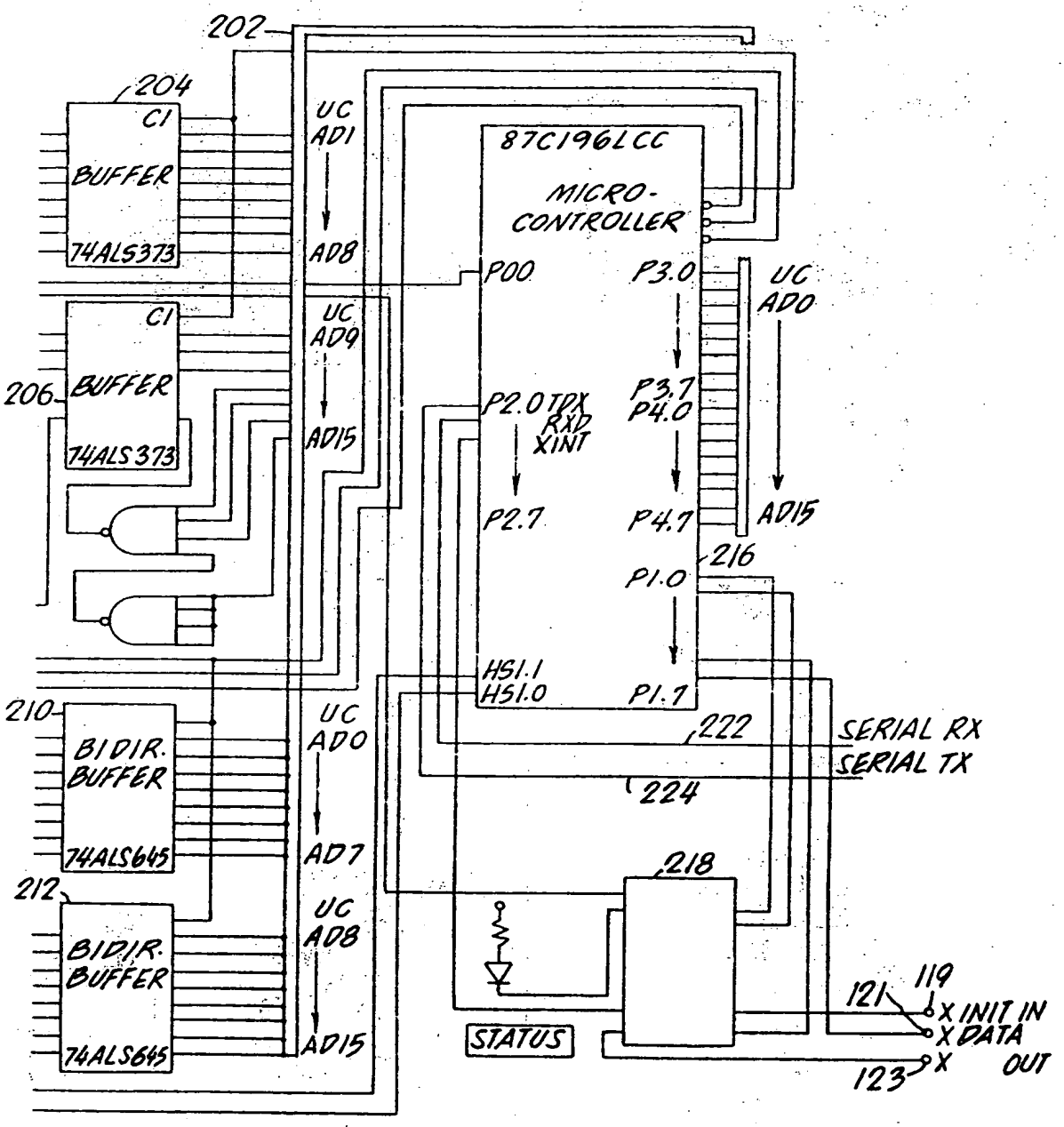
202
204
C1
BUFFER
74ALS373
UC AD1
AD8
87C196LCC
MICRO-CONTROLLER
P00
P3.0
UC AD0
206
C1
BUFFER
74ALS373
UC AD9
AD15
P2.0 TDX RXD XINT
P3.7 P4.0
P2.7
P4.7
AD15
216
P1.0
HS1.1
HS1.0
P1.7
210
BIDIR. BUFFER
74ALS645
UC AD0
AD7
222
SERIAL RX
SERIAL TX
224
212
BIDIR. BUFFER
74ALS645
UC AD8
AD15
218
STATUS
119
121
X INIT IN
X DATA
123
X OUT

FIG. 5B

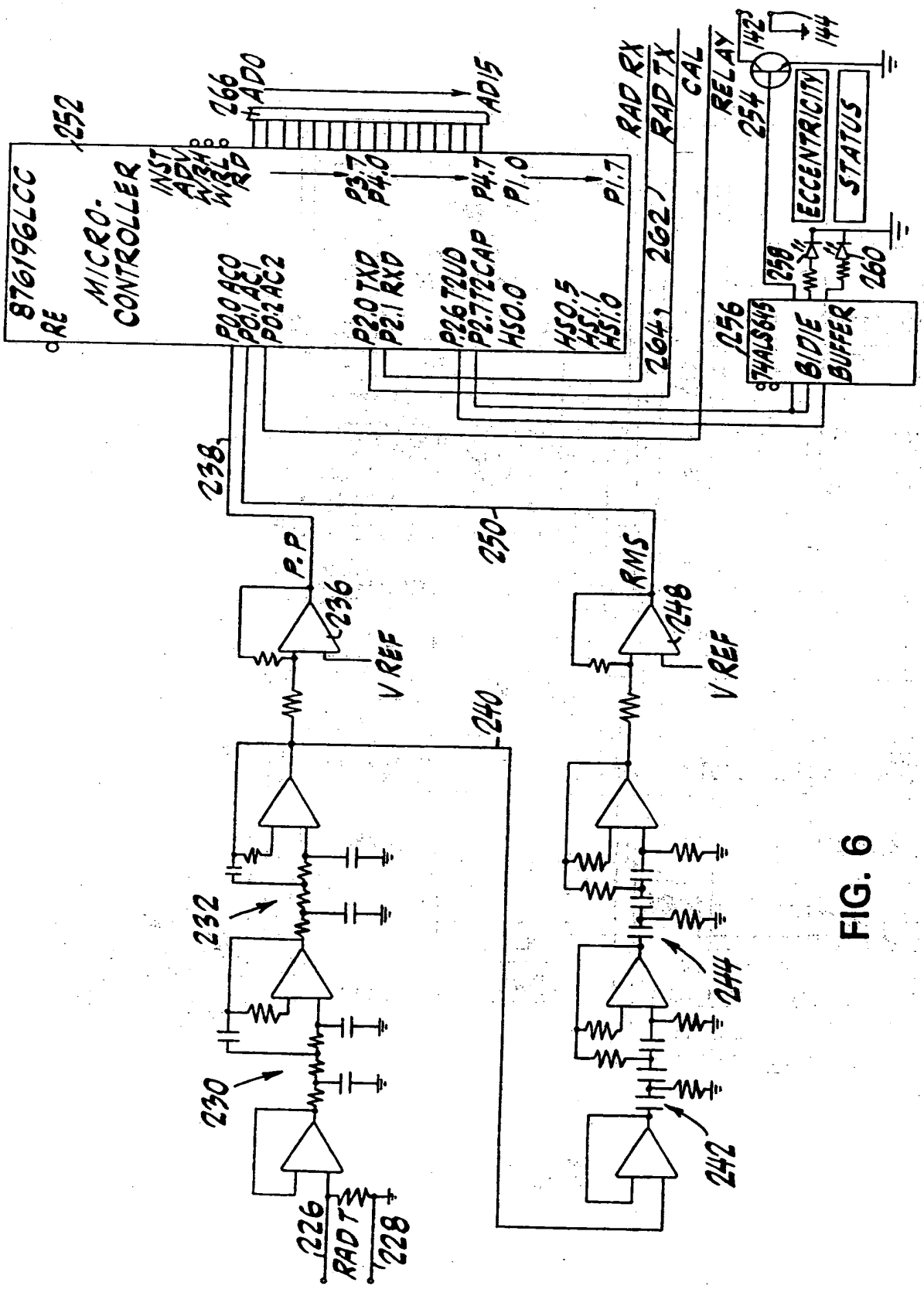
87C196LCC
MICRO-
CONTROLLER
252
RE
INST
ADV
WR
RD
266
AD0
AD15
P3.7
P4.0
P4.7
P1.0
P1.7
RAD RX
RAD TX
CAL
RELAY
254
142
144
ECCENTRICITY
STATUS
258
260
74ALS645
BIDIR
BUFFER
256
P0.0 AD0
P0.1 AD1
P0.2 AD2
P2.0 TXD
P2.1 RXD
P2.6 T2UD
P2.7 T2CAP
HSO.0
HSO.5
HSI.1
HSI.0
264
262
238
250
P-P
RMS
236
248
V REF
V REF
240
232
230
244
242
226
RAD T
228

FIG. 6

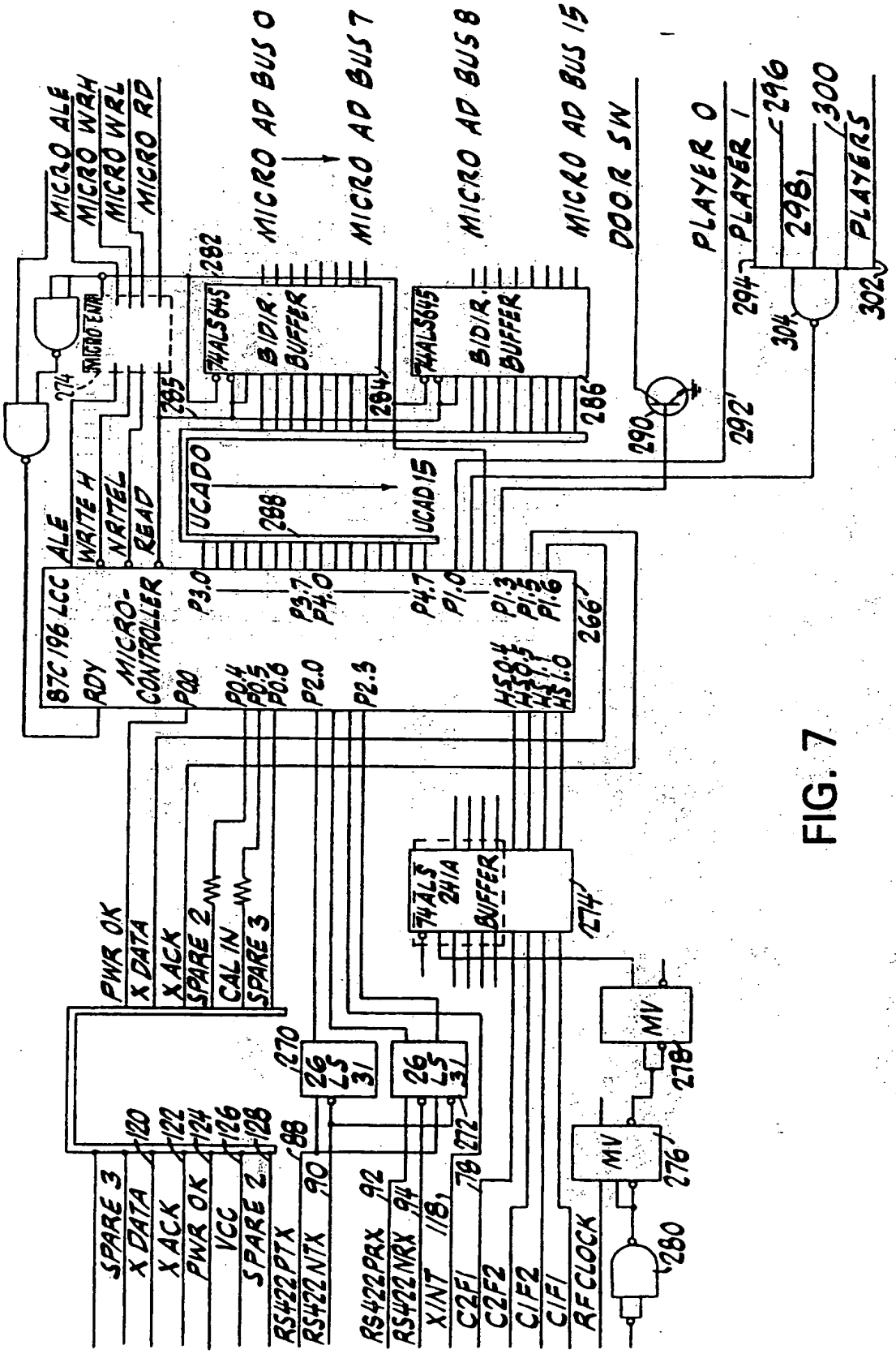
MICRO ALE
MICRO WRH
MICRO WRL
MICRO RD
MICRO AD BUS 0
MICRO AD BUS 7
MICRO AD BUS 8
MICRO AD BUS 15
DOOR SW
PLAYER 0
PLAYER 1
PLAYERS
282
285
284
286
288
290
292
294
296
298
300
302
304
274
SYNCRO ENA
74ALS645
BIDIR. BUFFER
UCAD0
UCAD15
87C196 LCC
MICRO-CONTROLLER
ALE
WRITE H
N.RITEL
READ
RDY
P3.0
P3.7
P4.0
P4.7
P1.0
P1.3
P1.5
P1.6
266
P00
P0.4
P0.5
P0.6
P2.0
P2.3
HS0.4
HS0.5
HS1.1
HS1.0
74ALS 241A BUFFER
274
PWR OK
X DATA
X ACK
SPARE 2
CAL IN
SPARE 3
270
26 LS 31
MV
278
276
280
120
122
124
126
128
88
90
92
94
118
272
78
SPARE 3
X DATA
X ACK
PWR OK
VCC
SPARE 2
RS422 PTX
RS422 NTX
RS422 PRX
RS422 NRX
XINT
C2F1
C2F2
C1F2
C1F1
RFCLOCK

FIG. 7

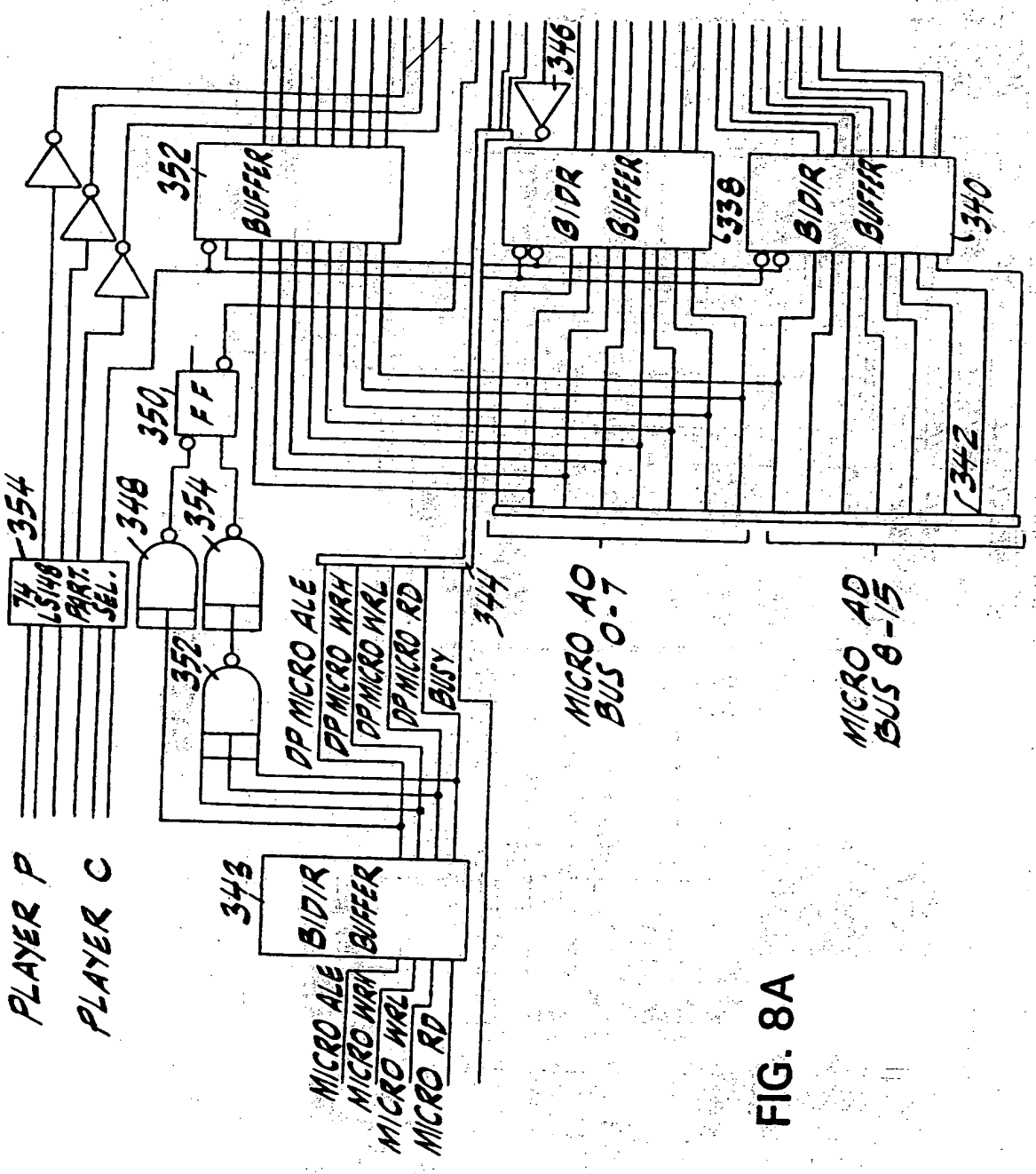
PLAYER P
PLAYER C
74LS148 PART SEL.
354
348
350
FF
352
BUFFER
346
338
BIDIR BUFFER
340
342
344
DP MICRO ALE
DP MICRO WRH
DP MICRO WRL
DP MICRO RD
BUSY
MICRO AD BUS 0-7
MICRO AD BUS 8-15
343
BIDIR BUFFER
MICRO ALE
MICRO WRH
MICRO WRL
MICRO RD

FIG. 8A

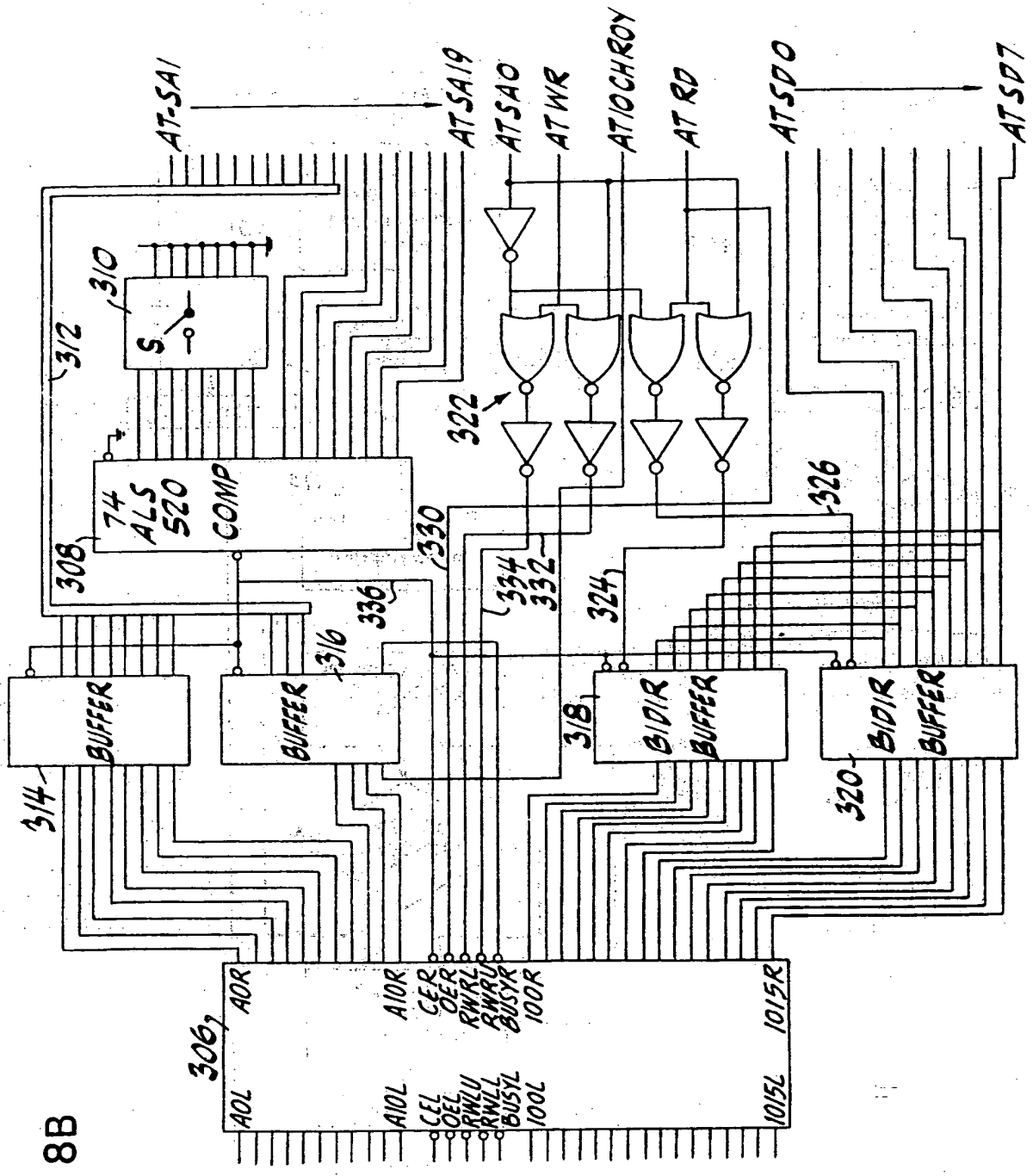
AT-SA1
AT SA19
AT SA0
AT WR
AT IOCHROY
AT RD
AT SD0
AT SD7
310
S
312
322
74 ALS 520 COMP
308
330
326
334
332
324
336
316
318
BUFFER
BIDIR
BUFFER
314
320
306
A0R
A10R
CER
OER
RWRL
RWRU
BUSYR
100R
101SR
A0L
A10L
CEL
OEL
RWLU
RWLL
BUSYL
100L
101SL

FIG. 8B

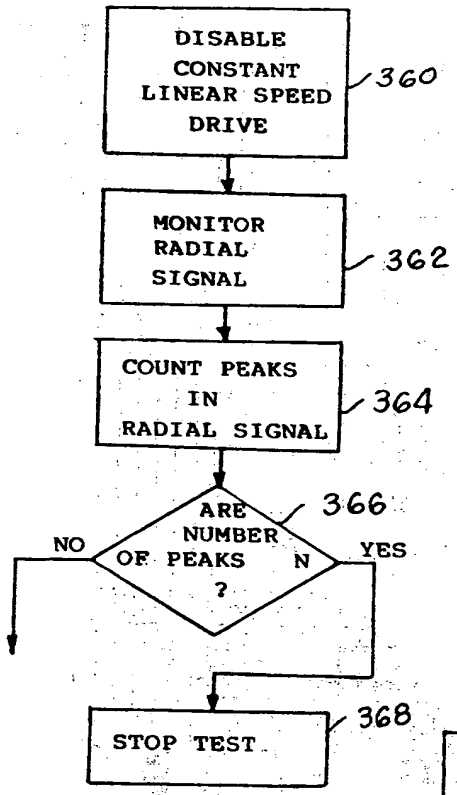
DISABLE CONSTANT LINEAR SPEED DRIVE
360
MONITOR RADIAL SIGNAL
362
COUNT PEAKS IN RADIAL SIGNAL
364
ARE NUMBER OF PEAKS N ?
366
NO
YES
STOP TEST
368

FIG. 9

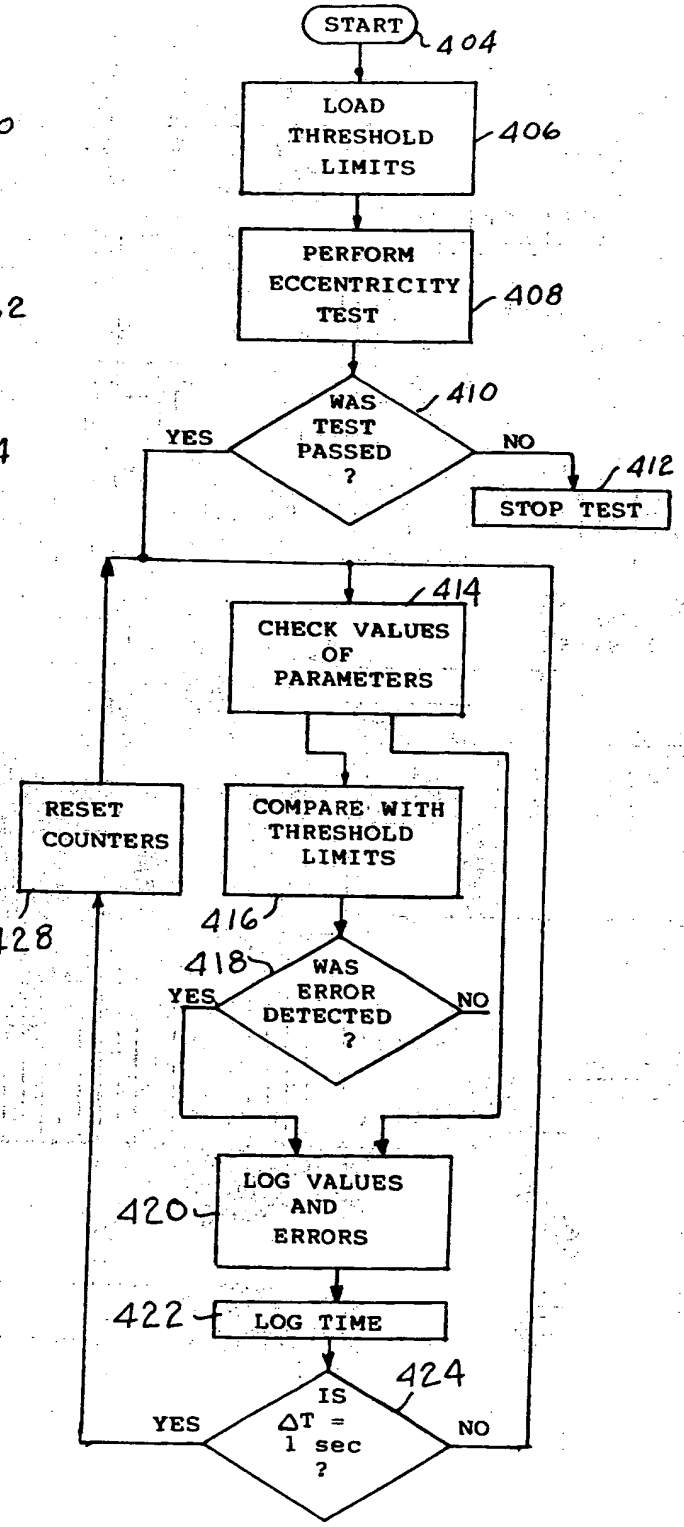
START
404
LOAD THRESHOLD LIMITS
406
PERFORM ECCENTRICITY TEST
408
WAS TEST PASSED ?
410
YES
NO
STOP TEST
412
CHECK VALUES OF PARAMETERS
414
RESET COUNTERS
428
COMPARE WITH THRESHOLD LIMITS
416
WAS ERROR DETECTED ?
418
YES
NO
LOG VALUES AND ERRORS
420
LOG TIME
422
IS ΔT = 1 sec ?
424
YES
NO

FIG. 12

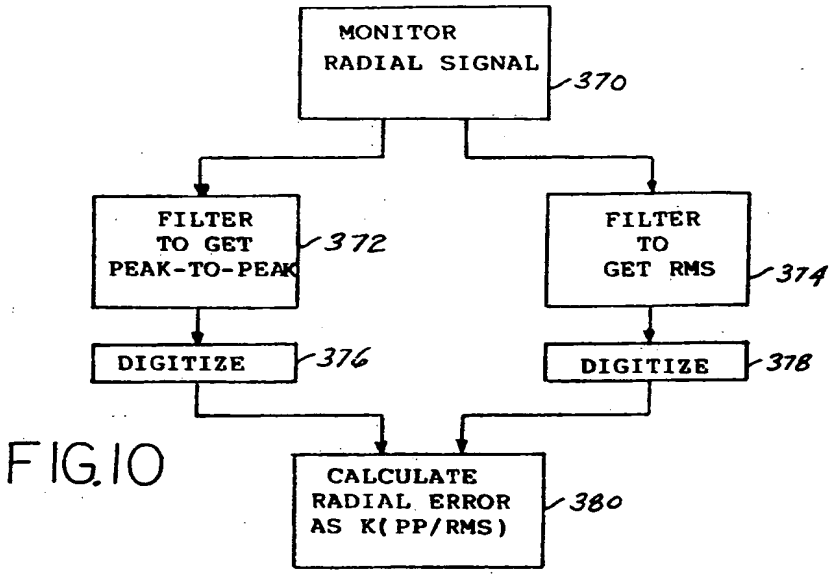
MONITOR RADIAL SIGNAL
370
FILTER TO GET PEAK-TO-PEAK
372
FILTER TO GET RMS
374
DIGITIZE
376
DIGITIZE
378
CALCULATE RADIAL ERROR AS K(PP/RMS)
380

FIG.10

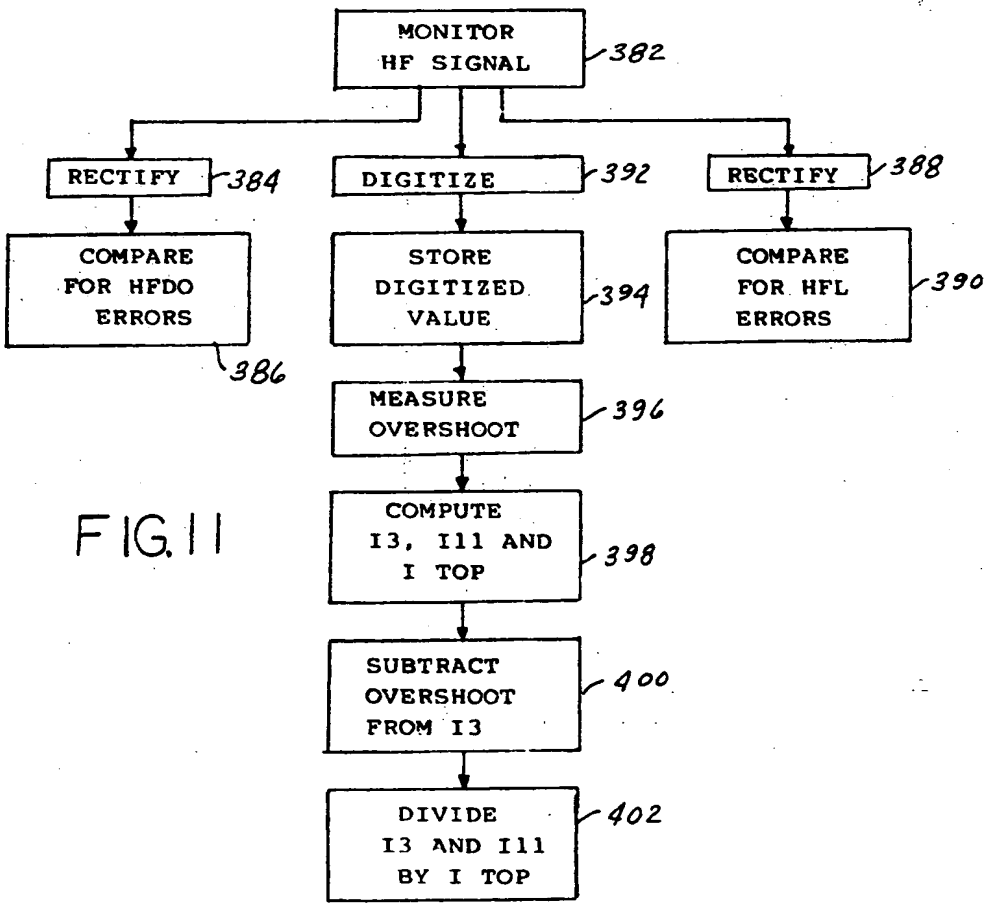
MONITOR HF SIGNAL
382
RECTIFY
384
DIGITIZE
392
RECTIFY
388
COMPARE FOR HFDO ERRORS
386
STORE DIGITIZED VALUE
394
COMPARE FOR HFL ERRORS
390
MEASURE OVERSHOOT
396
COMPUTE I3, I11 AND I TOP
398
SUBTRACT OVERSHOOT FROM I3
400
DIVIDE I3 AND I11 BY I TOP
402

FIG.11

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